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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Assistant Commissioner for Patents
Alexandria, VA 22313
BOX PROVISIONAL APPLICATION

Attorney Docket No.: 040257P1
Date: March 4, 2004
Express Mail Label No.: EV384115198US

INVENTOR(S)

Given Name (first and middle[if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Zhi-Zhong	Yu	San Diego, California

☐ Additional inventors are being named on the sheet attached hereto

TITLE OF THE INVENTION (280 characters max)

METHOD TO PROVIDE A SMOOTH TRANSITION BETWEEN ADJACENT GMSK AND 8PSK BURSTS

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Attn: Philip R. Wadsworth, Vice President, Intellectual Property Administration
Address: 5775 Morehouse Drive
City: San Diego **State:** California **Zip Code:** 92121-1714
Country: USA **Telephone:** (858) 651-4404 **Fax:** (858) 658-2502

ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages: 42 ☐ Drawing(s) Number of Sheets:
☐ Other (specify): _____

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.
☒ No
☐ Yes, the name of the U.S. Government Agency and the Government contract number are: _____

Respectfully submitted,

SIGNATURE : [signature] DATE: March 4, 2004

TYPED or PRINTED NAME/REGISTRATION NO.: Timothy F. Loomis, Registration No.: 37,383

TELEPHONE NO. : (858) 845-8355

(TRANSPROV.VER1.5-6/12/2001)

More Detailed Description of Invention Disclosure: -

Method to Provide a Smooth transition between adjacent GMSK and 8PSK bursts (EGPRS/EDGE)

Describe the problem solved and the advantage(s) of the invention:

Defined by ETSI GSM 05.04, EDGE (EGPRS) uses two modulation schemes, GMSK and 8PSK. The two modulation schemes are different in many ways. The most obvious one is that GMSK has constant amplitude, while 8PSK has variable amplitude. GMSK only modulates the phase and keeps the amplitude constant, while 8PSK modulates both phase and amplitude. By doing this 8PSK triples GMSK transmitting data rate.

The introduction of EDGE (and GPRS) means in the near future will be able to make a voice call while the MS is doing data call. That often requires both GMSK and 8PSK modulations in time slot next to each other. This means that both modulation schemes can be in the same spectrum and can appear in two adjacent bursts on both downlink and uplink. For downlink Tx BS normally does not switch off (ramp down) at end of each burst, as it needs to Tx in the next burst. For uplink, when there are two adjacent time slots, similar to BS, it is desirable not to power down at the end of the first burst and power up at the beginning of the next one. As the power is on in the guard period (GP), it has to be controlled carefully to minimise the interference to others. Spec has defined a spectrum mask for the transition. It needs joint efforts from both baseband and RF to satisfy the requirement and it is desirable to keep the emission as low as possible. This proposal concems the baseband technique which provide necessary condition to achieve the goal.

If both of the bursts are of the same modulation, the transition can be smoothly made as what BS always does for GSM, even with different power level. If the two bursts are of different modulations, i.e. GMSK followed by 8PSK, or the other way, the issue arising from such case is that the direct transition between the two modulations often generates spurious spectrum from the output stage of baseband signal, which will appear in RF and cause violation of the mask. Therefore it is necessary condition for both BS and MS baseband to be able to handle transition between adjacent GMSK and 8PSK bursts without generating unwanted frequency components. Currently there is no such application a/v in the real network around world, but in the near future, when EDGE is rolled out, user may want to make a voice call while surf the web (DTM). It is a practical issue and technical challenge for the new service in the near future. ETSI did not mention anything about the G-8 transition method. It only provide the masks to be satisfied.

Direct Interpolation between two modulation bursts might be used to make the transition smooth. However spurious spectrum could not be effectively controlled. Basically interpolation introduces a third modulation, which is neither GMSK nor 8PSK. It would be ideal not to introduce any other modulations during GP.

We are looking into this issue and find the way to make the smooth transition without using any other modulations. There are specific codes for each modulation and specific time of switching to make the transition smooth. The advantage is that there is no foreign modulation involved and there is no added complexity to the HW. These codes and the time to start their modulation coupled with the switching time are found from over 30 million combinations of code through both modulations.

Describe how others have solved the stated problem:

There is no such service that encounter this issue at moment, however ETSI does imply such application could happen and indeed is a good feature and selling point in the foreseeable future.

Traditional way of dealing with such issue would be either of following approaches:

1. Power down /up
2. Use complicated hardware (in BS only)
3. Foreign modulation piecewise solution.

Approach 1 is not desirable, but can get away with the transition problem, not really solving the issue.

Approach 2 is expensive, only applicable to BS, and it is far from ideal solution.

Approach 3 might be the best way of the three as long as it works. The fact is that this approach performance vary depends on the GMSK payload and point of process (even or odd symbol index). It introduces unnecessary modulation, which could be a source of interference to others in the network.

Based on our knowledge we are not aware of any one use the proposed approach.

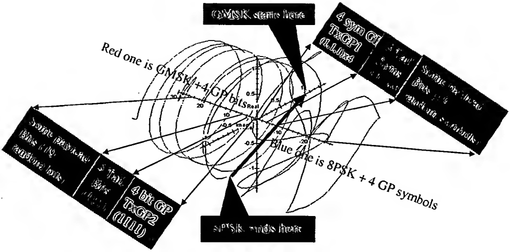
Brief description of the invention:

The proposed method is based on in-depth understanding of the details of the two modulations and their behaviour. It considers five factors of the two modulations, the amplitude, the amplitude rate of change, the phase and the rate of phase change and time when these happens. We have searched through all the possible combinations (more than 30 million) of the two modulations, and found groups of the codes at certain moment that all the above factors are in the right condition for smooth transition. The extensive search and post processing enable us to find specific codes and time of switching. The detail is related with the constraint of the HW (the way it produces the two modulations, but the general methodology applies to any two modulators that can produce 8PSK and GMSK).

Describe how the invention solves the stated problem and achieves the stated advantage(s):

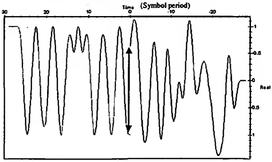
The problem

Generally the two modulations bear no relation with each other. They can start and end at any position in the constellation. One typical example is shown below where the two are not in the position to smoothly join each other by switching.

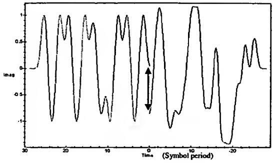


The I and Q observation shown below has obvious steps, which represent high frequency component.

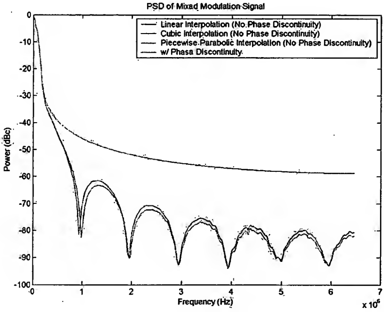
Real: I component



Imagery: Q



The spectrum of this kind of transition is shown below.



The issue is that the two modulations will not meet at the five conditions stated above. The problem of unwanted frequency components will arise if directly make such transition, either through line interpolation or direct switching. What is needed is an adaptive way, suitable for any payload, that bring the end of the two modulation close enough to achieve smooth transition.

Proposed resolution

With the switching codes and control of switching time stated above we can achieve a smooth transition between the two modulations:

Here is a special example that will work for the least flexible HW implementation. It assumes:

Modulation over sample rate (OSR): 48 samples/symbol

Modulation starting phase of GMSK: fixed (0^{o})

Modulation starting phase of 8PSK: fixed (0^{o})

GMSK switching code: 11111101

8PSK switching code: 06605

The two modulations signal (not the power) peak level ratio is 8PSK:GMSK = 1.521.

Transition phase: To show how it works as an example, suppose the first burst ends in such a way so that the first symbol of the switching code starts from 0^{o} (For those that starts from none 0 phases due to payload, they can be treated accordingly, simple enough to implement, this is just an example). Make sure the starting time of the next burst modulation is set so that the code in red are aligned with each other. The next burst switch code start from 0 phase.

Switching time: As this example is using OSR48, there will be 48 points for each symbol period. Let's assume that the point right at the beginning of a symbol is indexed with 0 and the point right at the end of the symbol is indexed as 48, or 0 of the next symbol. During the symbol period of the red code, switch right after the 13^{th} point.

Result at the point of switching:

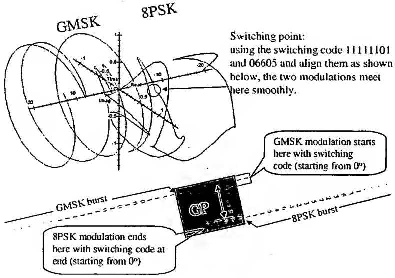
1. GMSK amplitude: 1, 8PSK amplitude: 0.999566. Matching well, the difference is less than 1 bit of 12-bit DAC

2. Amplitude change rate: GMSK: 0; 8PSK: -0.0166/step: within the range of 8PSK. (C0 allow 0.02/step, OSR48, the modulation would allow more)

3. GMSK phase: 24.375°. 8PSK phase:22.583°

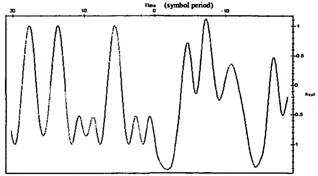
4. Phase change rate GMSK: 1.875°/step. 8PSK: 0.869°/step

5. Phase changing direction: both are anti-clock wise.



Both I and Q of this approach are smooth as shown below.

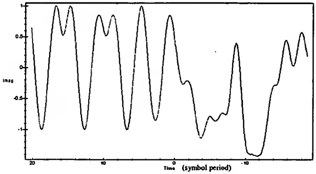
Real : I component



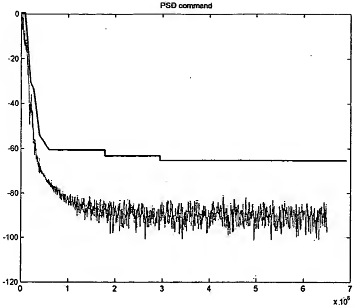
GMSK 8PSK

Imagery : Q component

GMSK 8PSK



The spectrum of them is shown below, and as expected, no obvious spurious frequency components were generated from such transition. The read lines are the 8PSK mask defined in 3GPP TS 45.005.

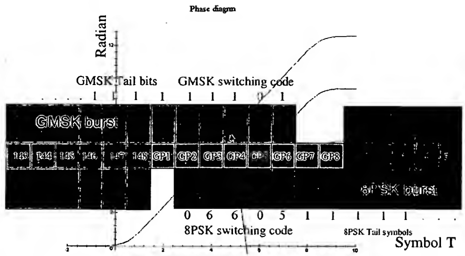


It should be noted that the baseband only provide necessary condition, not the sufficient condition. It must be combined with RF techniques to tackle the issue, including the power level change between the two bursts. The above technique can be used in flexible way, in terms of the codes and switching symbol. The examples here are for demonstration purposes, and in practice it can be different, depends on the RF requirement.

Depend on the code selected; the switching time normally would be different. For general case there are four possible variants for the selected code. The pattern is exactly the same, but with 90° rotation. This is due to the GMSK ending symbol phase is related with its index and the payload. If the modulators start from 0° or 90° or 180° or 270° for the first symbol. The 8PSK→GMSK transition should always be at even symbols counting from the first 8PSK symbol to the switching 8PSK symbol. This is to ensure the switching symbol is on the axis where modulations can start.

Another important factor is the starting phase of the switching code. They should be aligned for the switching code.

As an example here is the illustration of the above example: The read curve shows the GMSK symbol phase from the ending tail bit to the GP, the starting phase can be an arbitrary value, in this case 0°. The switching symbol is arranged to be the fourth GP symbol. We should be able to find the first switching code phase which is 270°. For this set of the code, the 8PSK switching code should be leading by 90°. So we start 8PSK modulation from 360° (or 0°). Then we can switch at the 13th OS48 point. They can be easily implemented (sounds more complicated than the actual code).



GMSK switching code start at 270°. 8PSK switching code starts from 360°, and meets GMSK switching code here smoothly.

What projects/products/standards does it apply to?

Mobile phone, base station and modem of telecomm industry. It can apply to EDGE capable devices.

How is it going to make us money?

Two ways:

Better way of doing fundamental data transmission in our chip would win more customers. This is one way of making money.

As we know spectrum is expensive and there is strict requirement on the RF resource usage. Everyone in this field sooner or later needs to resolve such issue, and there is no better way to achieve it by changing the codes and applying right time for switching. Others may use this method and pay royalty. This is another way of making money.

How is it going to give us a competitive edge?

Easier and better way of modulation transition will attract operators to use our solution, as this will have impact on the network performance.

The performance will attract others to use the same kind of transition approach. If we have patent on it and put it in standard, we will be in advantage position on this issue.

How easy is it to design around?

There are other ways around, but it is going to cost more and introduce foreign modulations. It may not guarantee the performance (generates unwanted spectrum).

How easy is it to detect when others are using it?

It is very easy to find, as the RF signal over the air will reveal itself what codes and method has been used. With our burst analyser, we can find from baseband raw measurements. Or just measure its code in the guard period and decode them.

Will it be built into a standard?

Could be but not have to.

As this is not only for MS, but also for BS. The specified method will reduce the interference in the network, hence the performance would be better. Good for generating revenue.

Give details here of when the idea was conceived, simulated and/or tested: -

Invention conceived on: -	11/09/2003	(MM/ DD/ YYYY)
Simulation completed on: -	26/11/2002	(MM/ DD/ YYYY)
Device Tested on:		(MM/ DD/ YYYY)

Identify here any related invention disclosures, patent applications and patents:

Inventors:

	Inventor 1 (primary)	Inventor 2	Inventor 3
Legal Name (e.g. John A. Smith)	Zhi Zhong Yu	Philip Children	
Alias (e.g. jsmith)	zyu	pchildre	
Office	ENGLD.B-1	As for inventor 1	
Address	c/o Qualcomm (UK) Ltd, 279 Farnborough Rd GU14 7LS		
Department	6348 - QUALCOMM UNITED KINGDOM LTD		
Telephone no. (work)	+44 1252 379219	+44 1252 399 164	

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TRANSITION BETWEEN GMSK AND 8PSK BURSTS

A fine tuned interpolation approach….

Zhi-Zhong Yu
Philip Children

Outline

- What is it?
  - An adaptive interpolation: the extreme case
- How to find it?
  - The procedures of finding the solution
- How does it work?
  - A visual example of 8PSK →GMSK
- How about the performance?
  - Spectrum analysis and comparison (fixed point)
- How to implement it?
  - Simple adaptive implementation and illustrations

An extreme case of interpolation method…

- As one of the follow up action items of system HLD review, with Kuei's expert collaboration, we fine tuned the interpolation method for the transition between GMSK and 8PSK bursts. An adaptive approach has been used to achieve smooth transition.
- A set of GMSK and 8PSK switching codes, and time of the switching were found to be useful for smooth transition without introducing foreign modulations. This is an extreme case of interpolation but with 0 interpolation point for OSR48.
- With joint effort, the initial spectrum analysis of this transition has been made. As shown by following slides, no obvious spurious frequency components were found. It proves that it has no more spectrum than those of 8PSK and GMSK. Therefore it could be one of the possible solutions to this issue.

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Four steps to find the switching codes and time

The aim is to find a point in both modulations that has

- same amplitude,
- same phase, and
- similar change rate of amplitude and phase.
- More importantly at the same time

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Step 1: Find possible switching point on 8PSK

- Search for a 5-symbol-long 8PSK codes that can provide the right amplitude for the transition
- A list of 8PSK codes were obtained from calculation of 30 million points. Table below shows the code sequence (06605), the OSR index of the middle symbol, amplitude and phase with the difference to the previous OS point.
- Here is one candidate whose switching code is 06605. We are particularly interested in OS point 13 to 14 and its 8PSK phase pattern.

I[1~5]	0	6	6	0	5	j	7	amp	1.098419	phase	17.11954	dif	-0.009845	dif_arg	0.977034
I[1~5]	0	6	6	0	5	j	8	amp	1.088899	phase	18.11395	dif	-0.00952	dif_arg	0.994412
I[1~5]	0	6	6	0	5	j	9	amp	1.079712	phase	19.1256	dif	-0.009186	dif_arg	1.011643
I[1~5]	0	6	6	0	5	j	10	amp	1.067387	phase	20.05896	dif	-0.012324	dif_arg	0.933361
I[1~5]	0	6	6	0	5	j	11	amp	1.050093	phase	20.87283	dif	-0.017294	dif_arg	0.813868
I[1~5]	0	6	6	0	5	j	12	amp	1.033017	phase	21.71378	dif	-0.017075	dif_arg	0.840949
I[1~5]	0	6	6	0	5	j	13	amp	1.016171	phase	22.5828	dif	-0.016845	dif_arg	0.869024
I[1~5]	0	6	6	0	5	j	14	amp	0.999566	phase	23.48091	dif	-0.016604	dif_arg	0.898103
I[1~5]	0	6	6	0	5	j	15	amp	0.983216	phase	24.40912	dif	-0.01635	dif_arg	0.928213
I[1~5]	0	6	6	0	5	j	16	amp	0.967132	phase	25.36847	dif	-0.016083	dif_arg	0.959345
I[1~5]	0	6	6	0	5	j	17	amp	0.951329	phase	26.35997	dif	-0.015803	dif_arg	0.991504
I[1~5]	0	6	6	0	5	j	18	amp	0.93582	phase	27.38466	dif	-0.015509	dif_arg	1.024683
I[1~5]	0	6	6	0	5	j	19	amp	0.92062	phase	28.44352	dif	-0.015199	dif_arg	1.058867

Question: during the period of 13 to 14 as shown above, is there a GMSK modulation point that could smoothly carry on from there ? YES….

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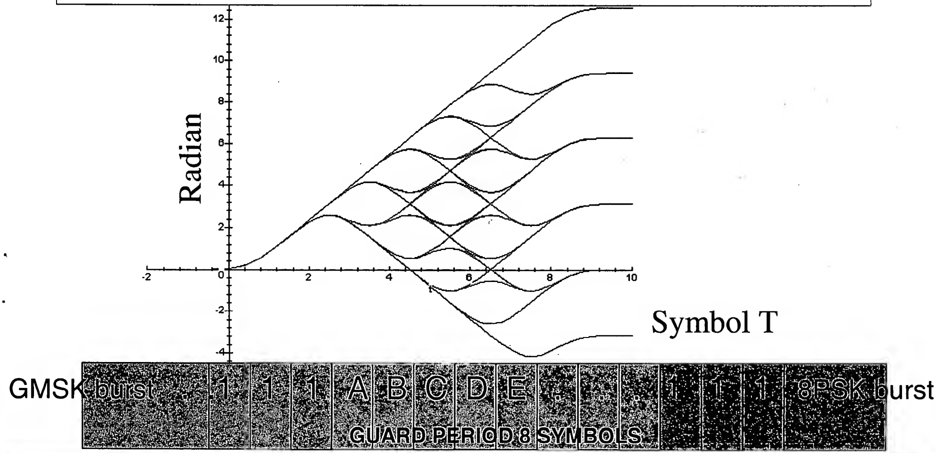
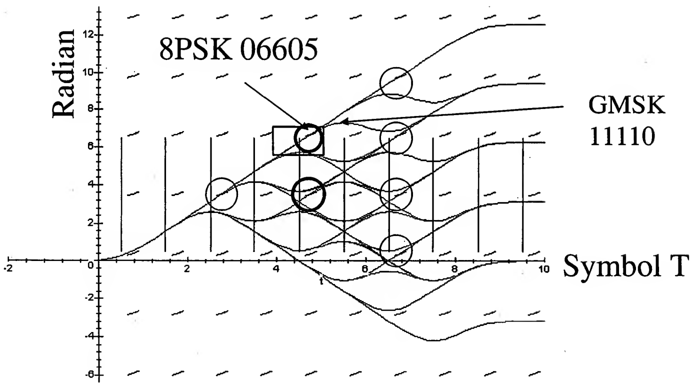
Step 2: Find all possible GMSK phase vs. time:
32 possibilities starting from 111



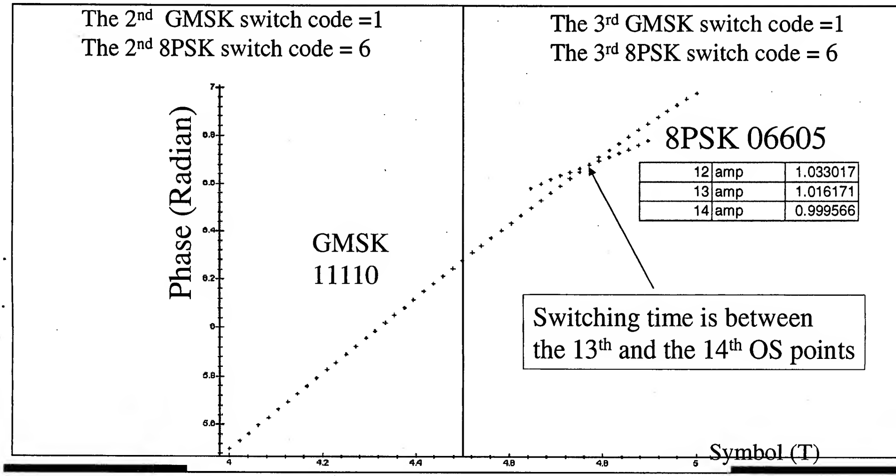
Step 3: Superimpose "8PSK pattern" on to GMSK traces

Phase diagrm



7 possible switching points are circled. Let's zoom in…

Step 4: Zoom in of 11110 with 06605 to find switching time to be …



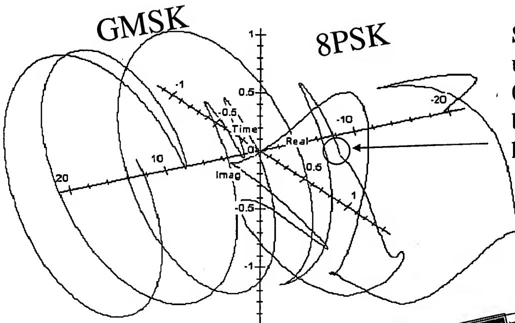
12	amp	1.033017
13	amp	1.016171
14	amp	0.999566

A visual example of 8PSK →GMSK

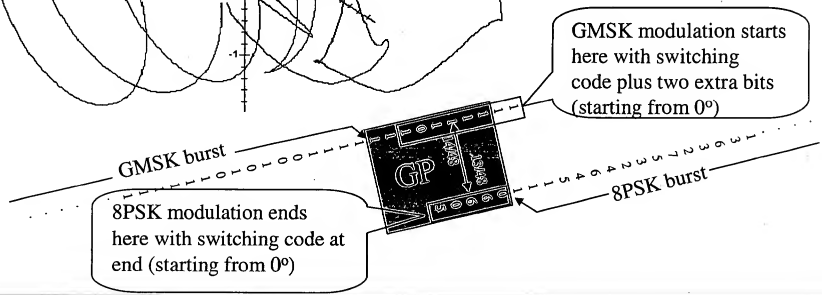
Get a feeling of

- How does it works ?
- Where is the switching point ?
- Does it look smooth?

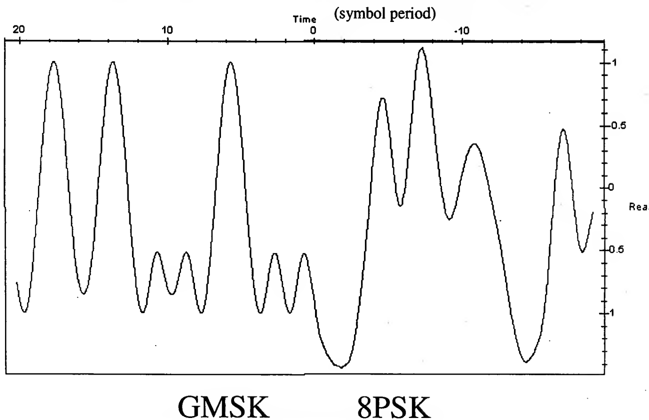
An example of 8PSK → GMSK transition



Switching point:
using the switching code 11101 and 06605 and align them as shown below, the two modulations meet here smoothly.

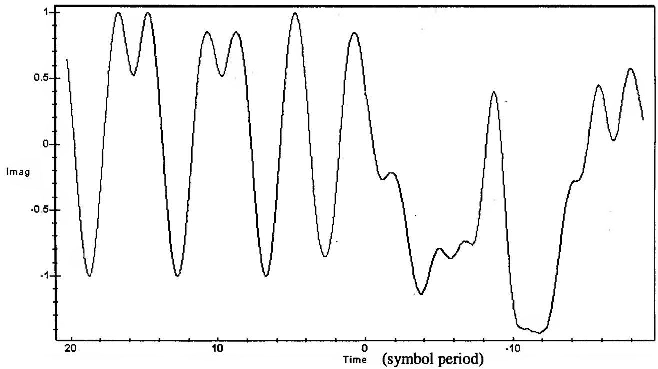


I component: Plot of Real sequence around the 8PSK → GMSK transition



Q component : Plot of Imagery sequence around 8PSK →GMSK transition

GMSK 8PSK



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Baseband smooth transition

- The spec defines the RF spectrum due to modulation and transition. This implies that Baseband not only needs to satisfy them, but also leave enough headroom for RF to play. Therefore Baseband smooth transition is a necessary condition not a sufficient condition.
- Ramp down/up is a RF activity where the best baseband can do is to provide smooth signal and provide suitable condition for RF to perform this activity.
- Working on Basedband, it would be important to understand the requirement from RF section, so that baseband provide suitable necessary condition.
- Based on the comments received on switching method, another set of switching codes are demonstrated in the next few slides.

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8PSK switching code 00011

I[1~5]	0 0 0 1 1 j	7	amp	1.096477	phase	109.3123	dif	-0.00479	dif_arg	1.289062	degree.
I[1~5]	0 0 0 1 1 j	8	amp	1.092247	phase	110.612	dif	-0.00423	dif_arg	1.299709	degree.
I[1~5]	0 0 0 1 1 j	9	amp	1.088583	phase	111.9211	dif	-0.00366	dif_arg	1.309135	degree.
I[1~5]	0 0 0 1 1 j	10	amp	1.081658	phase	113.2104	dif	-0.00693	dif_arg	1.289257	degree.
I[1~5]	0 0 0 1 1 j	11	amp	1.069522	phase	114.4799	dif	-0.01214	dif_arg	1.269561	degree.
I[1~5]	0 0 0 1 1 j	12	amp	1.057922	phase	115.778	dif	-0.0116	dif_arg	1.298051	degree.
I[1~5]	0 0 0 1 1 j	13	amp	1.046877	phase	117.1041	dif	-0.01104	dif_arg	1.326133	degree.
I[1~5]	0 0 0 1 1 j	14	amp	1.036405	phase	118.4578	dif	-0.01047	dif_arg	1.35367	degree.
I[1~5]	0 0 0 1 1 j	15	amp	1.026523	phase	119.8383	dif	-0.00988	dif_arg	1.380516	degree.
I[1~5]	0 0 0 1 1 j	16	amp	1.017248	phase	121.2448	dif	-0.00927	dif_arg	1.406519	degree.
I[1~5]	0 0 0 1 1 j	17	amp	1.008598	phase	122.6763	dif	-0.00865	dif_arg	1.431522	degree.
I[1~5]	0 0 0 1 1 j	18	amp	1.000587	phase	124.1317	dif	-0.00801	dif_arg	1.455364	degree.
I[1~5]	0 0 0 1 1 j	19	amp	0.993233	phase	125.6096	dif	-0.00735	dif_arg	1.477883	degree.
I[1~5]	0 0 0 1 1 j	20	amp	0.979094	phase	127.3307	dif	-0.01414	dif_arg	1.721122	degree.
I[1~5]	0 0 0 1 1 j	21	amp	0.963791	phase	129.1432	dif	-0.0153	dif_arg	1.812453	degree.
I[1~5]	0 0 0 1 1 j	22	amp	0.949483	phase	131.0122	dif	-0.01431	dif_arg	1.868997	degree.
I[1~5]	0 0 0 1 1 j	23	amp	0.936215	phase	132.9362	dif	-0.01327	dif_arg	1.924068	degree.
I[1~5]	0 0 0 1 1 j	24	amp	0.924033	phase	134.9133	dif	-0.01218	dif_arg	1.977081	degree.
I[1~5]	0 0 0 1 1 j	25	amp	0.909112	phase	136.949	dif	-0.01492	dif_arg	2.035679	degree.

Another set of 8PSK code 00111 or 00011 can be used to make "constant" GP amplitude. It also matches better than 06605. The switch point is at 18th point of the middle symbol 0, or the 30th point of the middle symbol 1.

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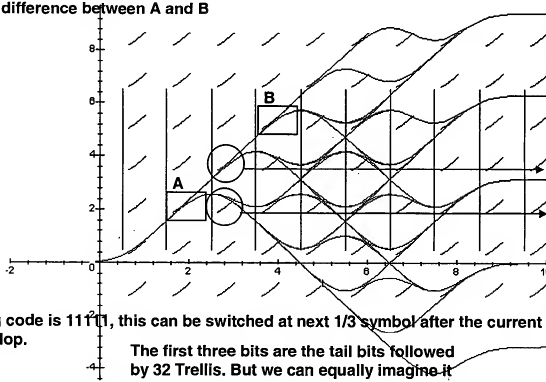
GMSK11111 8PSK 00011

Phase diagrm

There is difference between A and B



8PSK SC start
At the same ph
As GMSK
Corresponding
One:

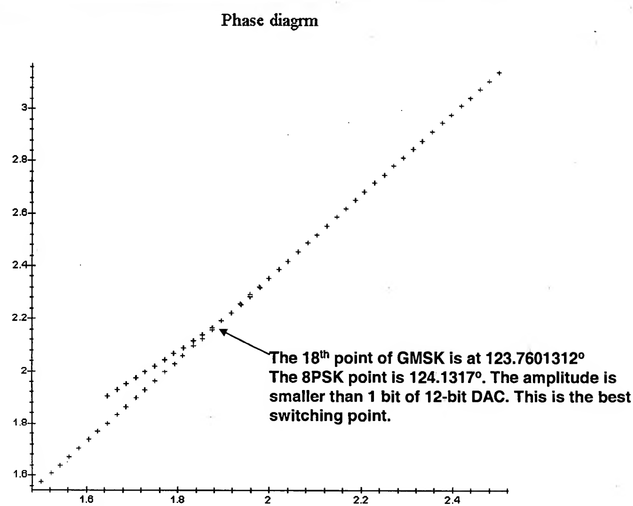
8PSK SC
Needs to
be lead
GMSK SC
starting
phase pi/2.

A is at 123.760 °
B is at 303.750 °
Should be fine.

As GMSK switching code is 11111, this can be switched at next 1/3 symbol after the current burst, making most of GP a constant envelop.

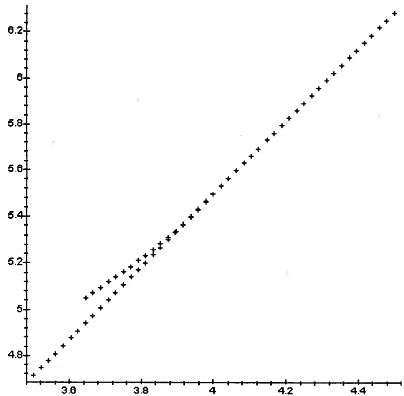
The first three bits are the tail bits followed by 32 Trellis. But we can equally ~~imagine it~~ is towards the GP in 11111, just need to be careful with the code and starting phase.

A zoom in


Phase diagrm
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.6
1.8
2
2.2
2.4
The 18th point of GMSK is at 123.7601312°
The 8PSK point is 124.1317°. The amplitude is smaller than 1 bit of 12-bit DAC. This is the best switching point.

B zoom in

Phase diagrm



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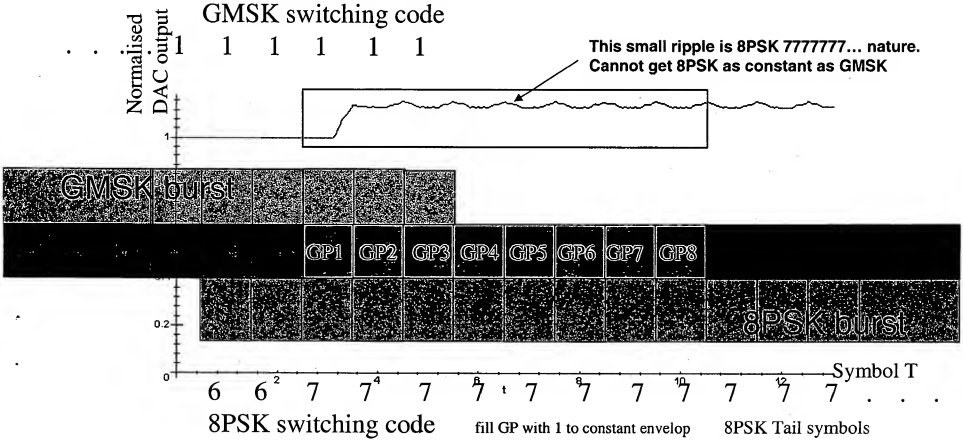
Amplitude variation in GP



GMSK switching code can be 11111. 8PSK switching code can be 66677, and the switching happens at GP1 to make most GP amplitude constant.

Question to RF experts

1. Is this amplitude profile in GP OK?

2. The previous slide shows the amplitude in GP when perform smooth switching from GMSK to 8PSK. This is with an early switching to 8PSK (switching at GP1). For obtaining constant amplitude we can also have a late switch to 8PSK (switching at GP8). Which is preferred? Should we keep GMSK as long as we can?

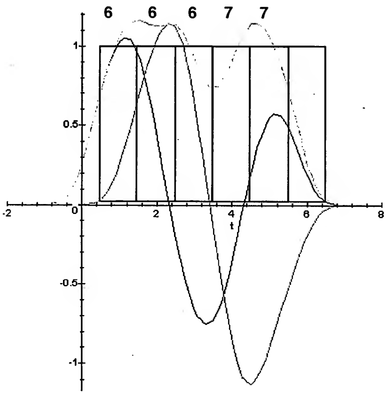
The priority might be related with following cases:

2.1 Should the switching point related with ramp down/up? I.e. is it better to have an early switching when it ramp up and last switching when it is ramp down, so that the switching points are always happen at low power rather than high power?

Or
2.2. Should the switching point related to the direction of switching GMSK → 8PSK or opposite direction.

2.3 If the above two are related, then there are four combinations of ramp down/up and directions. In each of the four cases how are we going to arrange it?

The lower down for 66677



Please note that if it is G28, there would be a step up which should take the switch at 66777, the phase of which need to be carefully studied (have not yet.

For 82G, there is a step down and the switch should be at 66677. This has been studied and know to be at 18 the point of OS.

Another set of data

- Switch at centre
- Directly from 111 to 777, four cases each has init 90° shift
- Need quick response to the data requirement
  - See the switching point:
    - » G28: goes high, switching at the 30th point;
    - » 82G: goes low, switch at the 18th point.
  - Shift from 000111 to 666777, shift by 90°, would be suitable for one case of GMSK
  - Plan for generating data: look at the GMSK landing

For matlab analysis 8G8 is better

- If you take extra 2.5 symbols at both ends, then there is a good 0 ends to avoid artificial windowing effect
- For FFT we can also make it G8G and take care of the ending points for FFT to repeat

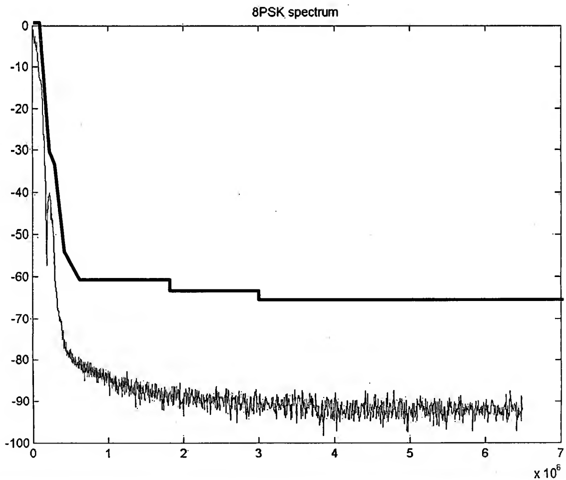
Start modulation in 45°

- Condition: Use 11111… and 7777…, and make the switching at GP4,
- There need to be 45° starting phase for GMSK.
- Even we shift switching point to GP3 or GP5, we only get 22.5° and 67.5° starting phase, which is worse than 45° starting phase, as with 45° the next round will come back to axis, while 22.5° will need 67.5°.
- The only possible place that allows axis starting point is GP2 or GP6 switching point.
- These are the options, nothing else under the condition above.
- For cyclic table, we just need 4 bursts.

Spectrum analysis of the transition

As the spec defines the spectrum mask, we have to judge the performance by spectrum analysis. A simple and possibly the worst scenario is analysed and it has been found to be as good as expected – no spurious frequency. In reality it should be better …

Spectrum for 8PSK only burst



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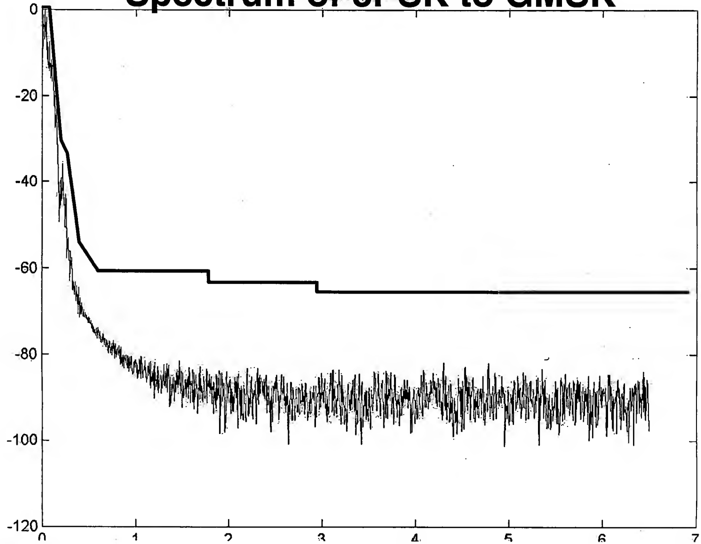
Spectrum of 8PSK to GMSK



The spectrum comparison

- Compared with 8PSK only and GMSK only (GMSK not included here) spectrums, the spectrum with the smooth transition between 8PSK and GMSK is well below the both masks and has no obvious spurious frequency components that beyond the spec. It is believed that its spectrum is no more than the combination of the two modulations. Therefore it is the ideal solution for GMSK and 8PSK transition from spectrum point of view.
- So far we have made an initial spectrum analysis of two bursts with random data from 8PSK to GMSK. More bursts with such transition can be formed to give better and smoother plot than this one. It is believed that the initial spectrum analysis does reflect its true spectrum with certain effect at bottom left corner due to window effect of the analysis.
- As GMSK and 8PSK has symmetrical ISI and burst format, GMSK to 8PSK transition spectrum would be the same as 8PSK to GMSK with this method
- As it satisfies the spectrum during useful part of the burst, there is no doubt that it will satisfy the transition spectrum of either GMSK or 8PSK

Implementation

- Decide the symbol of switching in GP
- Use the switching code two symbols earlier than the switching symbol with the correct switching code starting phase
- Switching between the 13^{th} and 14^{th} OSR48 points

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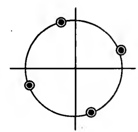
Four possible switching points

In general case, with GMSK switch code 11101, there are four possible switching points due to the GMSK modulation payload and the symbol index of the switching symbol. The four points are formed by 90° rotation of GMSK modulation.



To meet each of the four points, the 8PSK switching code can be obtained with the same rotations, keeping 06605 pattern. GMSK switching code starting phase should lag 8PSK by 90°.

For GMSK 11111 the symbol phase is slightly bigger than the baseband phase at last moment of the symbol period

This could be used to tell where the symbol is and work out the starting phase of the other it switches to.

Implementation case -- an example

- Practical implementation depends on modulators design. Below is one possible approach based on individually implemented GMSK and 8PSK modulators: (all angles mentioned below refer to symbol, not baseband OS points)
  - Due to the need for switching, both modulations run simultaneously in GP.
  - Suppose that modulation starts from 0° or 90° or 180° or 270° for the first symbol, and we are using OSR48. We switch between the 13th and 14th point of the 4th GP symbol, similar to what has been demonstrated previously.
  - For GMSK to 8PSK, suppose that the chosen GMSK switching code is 11101, filling 1 bit after the tail bit forms 1111101; the 8PSK switching code 06605 pattern can start from the 2nd GP symbol with 90° leading phase of GMSK switching code.
  - For 8PSK to GMSK, we need to make 8PSK switching code 06605 pattern start on even symbol of current modulation, with the first code that start from 90° . At the same time start GMSK modulation with 11101 from 0°.

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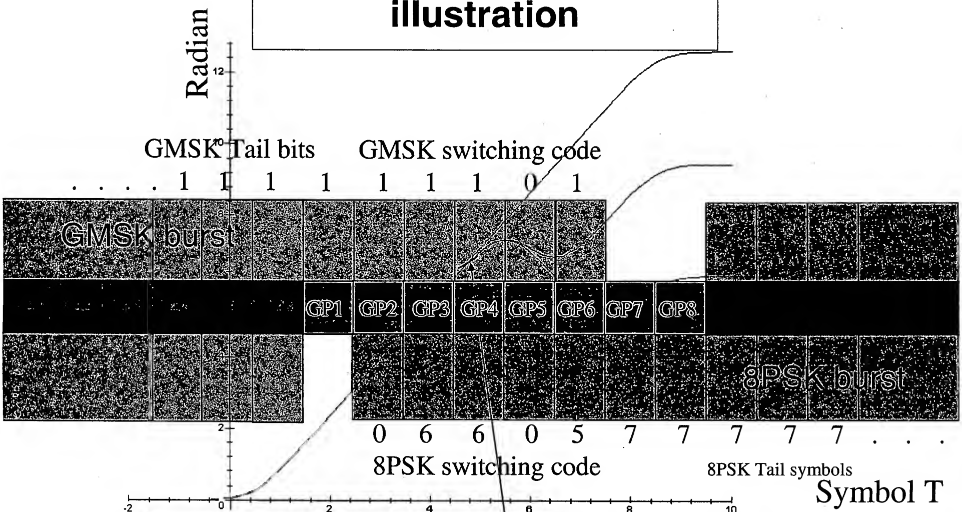
Implementation case illustration



GMSK switching code start at 270º. 8PSK switching code starts from 360º, and meets GMSK switching code here smoothly.

Conclusions

- A novel baseband modulation transition method has been demonstrated.
- It has smooth transition between consecutive 8PSK and GMSK bursts (in any order) without introducing interpolation points other than themselves for OSR48.
- The transition spectrum is no more than those of 8PSK and GMSK. Therefore it is the optimum transition method from spectrum point of view.
- This enables the baseband to take near 0 budget for the entire UL chain, which is important to satisfy the ETSI spec with good performance.
- As demonstrated, it could be one of the best solutions for the modulation transition issues.
- It is low risk and no compromise approach.